Ocean Surface Electrification for Enabling the Return of Refracted HF Signals in OTH RADAR Systems

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Introduction

High-Frequency Over-The-Horizon RADAR systems rely upon the ionosphere to reflect RADAR signals to detect aircraft which ordinarily could not be detected a result of limits created by the curvature of the Earth. In those systems, a RADAR signal is emitted which bounces off of the ionosphere, comes down to the level of aircraft and, after bouncing off of the aircraft, returns to the ionosphere, from whence it bounces a second time and then returns to ground level. Either ground stations or ships can be used to receive and analyze these HF signals to look for evidence of aircraft.

These systems are limited, both because they do not provide highly accurate positional fixes and because they rely upon a multitude of ground stations and/or ships to detect the RADAR signals after the second bounce. OTH RADARs are effective only insofar as we have some sort of listening posts beyond the area we are trying to measure. In the Pacific, we can protect Hawaii, for example, because we have ships well-beyond Hawaii in the Western Pacific which can act as receivers. In the Atlantic, OTH RADAR can protect the U.S. Eastern Seaboard because we can send ships into the East Atlantic and into the Arctic.

However, if we want to defend positions which are in the Arctic through an early-warning capability and without relying upon satellites (which could be disabled or destroyed in the opening moments of a military conflict,) we need to explore unconventional approaches to OTH capability.

Abstract

I propose that the existing system of HF RADARs can be leveraged in a different way through the electrification of the ocean’s surface. Ships, which feature powerful electrical generators, can introduce current into the water which can find a positive terminal in any one of many buoys designed to serve this purpose. Positive terminals can also be installed along coastline in places such as Greenland and in parts of Canada. These positive terminals would allow current to flow through the water. This current would change the properties of the water with respect to HF energy, causing it to be reflected just as it would be by the ionosphere.

When HF energy strikes an aircraft after an initial ionospheric bounce, most of the energy is re-directed to the ionosphere and continues to move, generally, away from the emitter. However, some small portion of this energy is *refracted* backward and upward, back toward the ionosphere in the direction from whence it came.

That energy can ultimately make it back to a receiver collocated with the emitter and to other strategically deployed receivers under our control.

This refracted portion of the signal would constitute a small portion of the overall energy, with most of it being reflected and continuing on in the direction of angular momentum. In order to gather enough of that energy to make use of it, we must look not only at the direct return after one ionospheric bounce along the inverse of the original route, but at energy which is scattered by the ionosphere toward the ocean's surface. Ordinarily, this energy would simply be absorbed by the water, but if the water is electrified over a wide area, it would bounce upward toward the ionosphere from whence it may bounce again. By looking not only for direct returns but for signals which undergo an artificially-enabled oceanic bounce prior to a secondary ionospheric bounce, the time-differential between the received primary signal and ocean-bounced signal can provide more accurate ranging information and a better ability to detect weak signals.

Thus, if this comparatively weak refracted signal could be reflected by the ocean's surface as it would be by the ionosphere and we could detect it after a subsequent bounce not only from the water but from the ionosphere, we could detect aircraft coming from well over the horizon in Russian territory by emitting HF northward, through the Arctic, thereby overcoming the problem of a lack of receiving stations under our control in Russia.

In summary, this newly proposed system would entail the installation of a number of positively charged electrical terminals which would allow for current; injected into the ocean by ships (saltwater being an excellent electrical conductor given its salinity;) to flow over a wide area of the surface of the ocean, bestowing the ocean's surface with a slightly negative electrical charge. Some of the refracted HF energy not redirected to follow the direct, reverse path of the path it took to get to the aircraft could be reclaimed through the aforementioned artificial change to the properties of the ocean water i.e. the ocean's surface would reflect it rather than absorb it, creating new opportunities for an ionospheric bounce which would ultimately allow that portion of off-axis energy to be detected.

HF energy would be emitted, would bounce once from the ionosphere, would interact with aircraft which are over the horizon, would be redirected in some small quantities on a reverse trajectory back toward the ionosphere and, ultimately, back to a receiver collocated with the transmitter. Some of the refracted energy would travel in directions which are not ordinarily useful, but the electrification of the ocean's surface would enable some of that lost energy to be bounced from the water and then bounced off of the ionosphere a second time prior to ultimately being detected by our sensors. That makes a total of four reflections and one refraction for the alternative stream of RF energy received through this detection system and only two reflections and a refraction for the primary stream.

Conclusion

Although the signal would be weakened, RADAR-absorbent coatings are not very effective in the HF band. Because the a receiver could, in this case, be

collocated with the emitter, if the signals could be detected, they would provide positional fixes of greater accuracy than when this system is used in the conventional mode as the trigonometric functions involved in inferring the positions of the OTH aircraft would be simplified. The addition of a refraction in the overall process would introduce, necessarily, a shift in the frequency of the returned signal which would allow for the receiver to be collocated with the emitter without any worry of the emitter deafening the receiver.

This mode of operation, although designed to overcome a specific shortcoming of the traditionally-used system, is actually superior for all use-cases as it allows for more accurate positional fixes both due to the practicality of collocating transmitter and receiver and as a result of the ability to perform a differential analysis upon both the reverse-path portion of the return and the separately-received oceanic-bounce four-reflection return. Positional uncertainty introduced by the natural variability in the average altitude of the ionospheric layer can be countered by the consistency of the position of the ocean, which would allow, amongst other things, for the effective altitude of bounce within the ionosphere to be extrapolated in order to use the primary return information more effectively. Such a system would also provide reasonably accurate altitude information for the aircraft.